Madaket Harbor / Long Pond
Annual Report
2005

Prepared for:
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Introduction:

Madaket Harbor and Long Pond make up a unique ecosystem encompassing approximately one quarter (9 sq. miles) of the surface area of Nantucket Island. These two systems are hydrologically connected via Hither Creek, and the Madaket Ditch. Historically, since the late 1600s the area was operated as a herring run, coincidentally there is now a ban on the taking of herring until January, 2009, by order of the Division of Marine Fisheries. Hither Creek is permanently closed to the taking of shellfish, and Madaket Harbor maintains a six month seasonal closure due to fecal coliform counts monitored by the DMF. As it is in the best interests of the Town of Nantucket to maintain water quality in this area, and re-open the closed beds for shell fishing, a great deal of water quality research has been done and continues to be done in this area.

The Woods Hole Oceanographic Institute conducted some of the first studies on Long Pond from 1989 – 1992, in an island wide study on fresh water ponds. They determined that the pond had become eutrophic as a result of nutrient loading, and was experiencing low oxygen events and large phytoplankton blooms. The Division of Marine Fisheries monitors fecal coliform with respects to shellfish contamination, and has conducted shoreline surveys, and circulation studies, with regards to this problem. Applied Science Associates of Rhode Island completed a computer model / circulation study of the area in 2002. Northeast Aquatic Research of Connecticut along with the Marine Department conducted two years of preliminary monitoring, ’01-‘02 to qualify for the Massachusetts Estuary Project. This study preformed by the School for Marine Science and Technology (SMAST), also assisted by the Marine Department is to provide a nutrient threshold limit for the Madaket system regulated by The Department of Environmental Protection. Town of Nantucket’s Department of Public Works is also working with Earth Tech on a Comprehensive Wastewater Treatment Plan to remediate some of the problems associated with this system.

Madaket Harbor is approximately 746 acres, semi circular in shape, open to Nantucket Sound on it’s western edge, and open to the Atlantic on it’s southwest corner via a cut between Smith’s Point and Tuckernuck. The Harbor is relatively a shallow water body, 4-5 feet deep, with a deeper channel (6-9ft.) running east and north to the coastline of the Sound. There are a few deeper channels that pre date Hurricane Esther, (1961), but much of the harbor has filled in as a result of the opening that was created by this storm. This condition existed until Hurricane Gloria, (1985) which closed the gap to Smith’s Pt. Because the southwest edge is open, circulation is high (flushing every 3 days), and water quality is good. Epiphytic, and macro algae are limited in presence and density, and eel grass beds are healthy.

Hither Creek is one of the connectors to Long Pond, as such it functions as an estuary with a noticeable salinity gradient. Approximately 40 acres, it is a narrow rectangular channel, connecting a boat yard to the harbor on it’s northeast end, and serving as a safe mooring field. The depth varies from 6-9 feet, and the bottom is composed of silt, sand, and mud. Water quality suffers moderate impairment due to high bacteria, and nutrient levels; despite it’s flushing time of 3 days.

Madaket Ditch connects Hither Creek to Long Pond, and runs through a 50 acre salt marsh; latticed by mosquito ditches which connect several small ponds. This area may be completely flooded during winter high tides. The ditch has depths between 2-4 feet, with little tidal variation on the pond end. The marsh acts as a nutrient sink, and intercepts an appreciable amount of nutrients from Long Pond before they reach the creek and harbor. The ditch flushes 4 times a day, but basically acts as bottle neck to Long Pond which flushes only once every 76 days at the North Head, and only once every 183 days at the southern end. So the water in the ditch is basically sloshing back and forth, with some exchange occurring on the creek end.

Long Pond, because of this circulation pattern, is somewhat isolated from the whole system, and may be evaluated as having separate water quality issues. This is not to say however that Long Pond is not a contributing factor to rising nutrients in the ditch, marsh, creek, and harbor. With a length of 1.8 miles, and 79 surface acres this is the largest of the salt / brackish water ponds on the island. It is also one of the more shallow ponds, only 4-6 feet deep with no deep basins. It is relatively narrow and winding, with a few isolated coves, and one large open circular area, (the North Head); which is a little grater than half the total size. Very nearly impassable in the late summer because of the prolific pond weed, water quality is poor, and may be defined as hyper-eutrophic. The State (DEP) would list it as “severely degraded” according to their coastal water nitrogen threshold guide, and the low oxygen events may no longer support suitable habitat for desired fish species.

Water quality monitoring of the Madaket Harbor / Long Pond system has been continued in 2005 to note any changes in the harbor, and to follow trends in the pond’s decline. Sampling includes temperature, dissolved oxygen, salinity, water transparency, and water quality constituents (nitrogen and phosphorus). Initially the plan was to sample just 4 sites in the harbor, but because the pond is connected, and a sampling regime had been established, 2 sites were added to include the pond. The sampling locations are as follows; **Site 1:** Hither Creek, **Site 2:** Jackson’s Pt., **Site 3:** Warren’s Landing, **Site 4:** Eel Pt., **Site 5:** Massasoit Bridge, **Site 6:** Long Pond / Madaket Ditch Culvert. These sites are located on **Map# 1**.

Monitoring Results:

Appendix A: contains all physical and chemical data taken for 2005. **Appendix B:** contains the averages of A, and graphs of that data. **Appendix C:** contains average monthly rainfall data for 2005, as collected by the Nantucket Water Company.

Average Temperatures and Average Dissolved Oxygen:

Temperature and dissolved oxygen are as relevant to the Madaket Harbor / Long Pond system as they are to Nantucket Harbor. These are vital physical parameters that will affect the flora, and fauna in the ecosystem. As these two conditions affect one another, they can be combined and discussed together. Because these water bodies are shallow, they are relatively isothermic throughout the water column. Temperatures and D. O. levels vary at different sites because of the size of the water body, fresh water inputs from the watershed, and varying conditions in the Sound and the Atlantic. Higher temperatures decrease the solubility of oxygen in water. Dissolved oxygen is lowered by this process, it is further lowered by the process known as biological oxygen demand, generated from respiration and the consumption of oxygen by anaerobic bacteria. Dissolved oxygen levels above 5 mg/l are a desirable condition for most aquatic species. Some species have a wide range of tolerances and may not be stressed until D.O. levels drop below 3 mg/l. Anoxic conditions exist when D.O. levels drop to 1 mg/l and below. Most fish, shellfish, and benthic organisms can not survive anoxic conditions for any length of time. A eutrophic state will also begin to occur as nutrients are released from soils during anoxic events, and nitrogen is recycled into the water column. The resultant affect of these conditions are the blooms of phytoplankton, epiphytic and macro algae; which eventually die increasing nutrients, decreasing oxygen, and decreasing habitat (eel grass).

The summer of 2005 showed relatively normal temperatures and dissolved oxygen levels for Madaket Harbor; (Sites 2-4). However in Hither Creek and Long Pond, (Sites 1, 5, and 6) temperatures were higher in July and August. This would be expected in a shallow water body with little circulation. When combined with a nutrient rich condition, dissolved oxygen levels often plummet into periods of hypoxia, and anoxia. Site 5 experienced the worst of these conditions, exhibiting a hyper-eutrophic state from July through October. Because of an abundant growth of pond weeds, Long Pond experiences super saturated levels of dissolved oxygen; average D.O. for July 12.71mg/l. Photosynthesis is responsible for this during the day. It would be expected however that respiration, the opposing condition occurring at night would be just as severe, resulting in anoxia. In August and October because of tides and the sampling time, the depth at Site 5 reached to 4ft. This created a stratified layer in the water column where borderline anoxic D.O. levels of 1.72mg/l and 1.21mg/l could be read. The consumption of decaying pond weed and phytoplankton, by anaerobic bacteria creates this anoxic level; which is ultimately the result of a nutrient enriched condition.

Figure 1: Average Temperatures

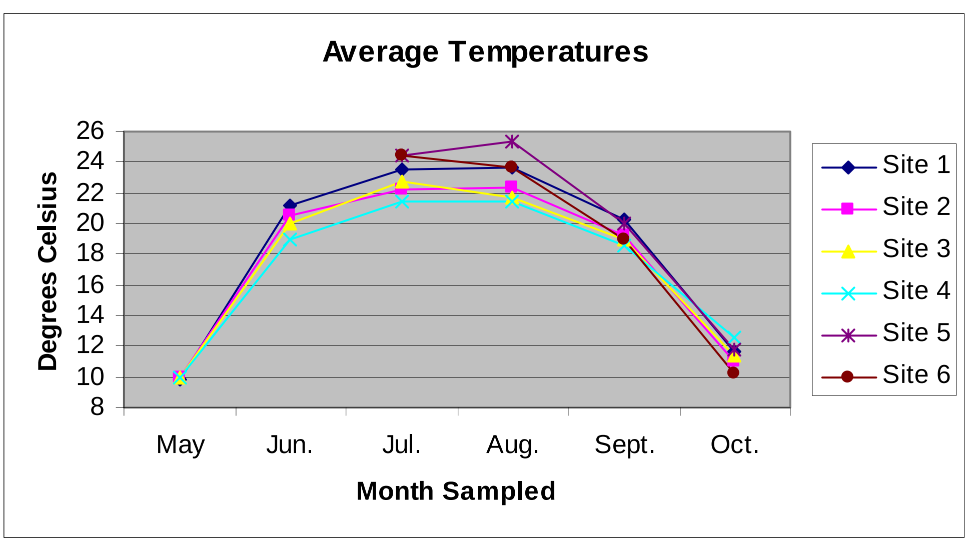
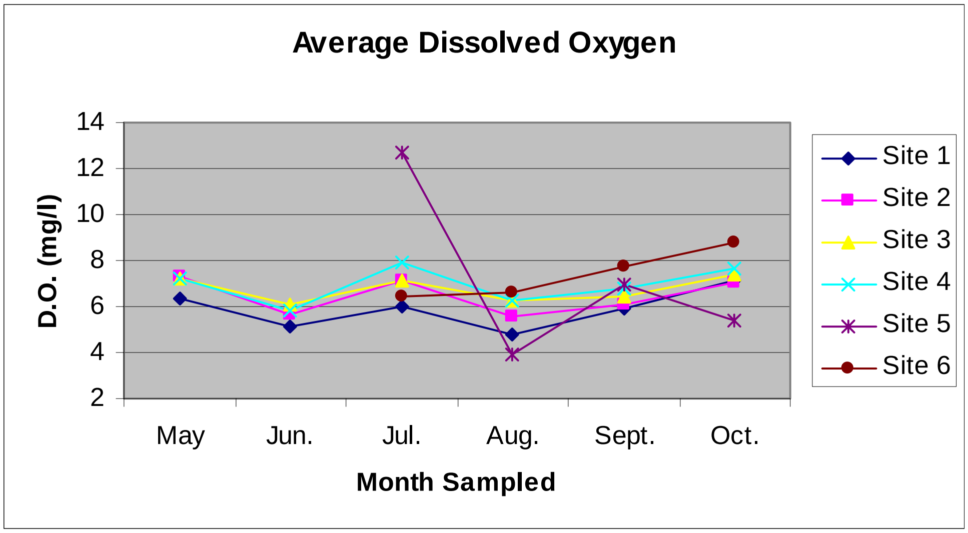


Figure 2: Average Dissolved Oxygen 2005



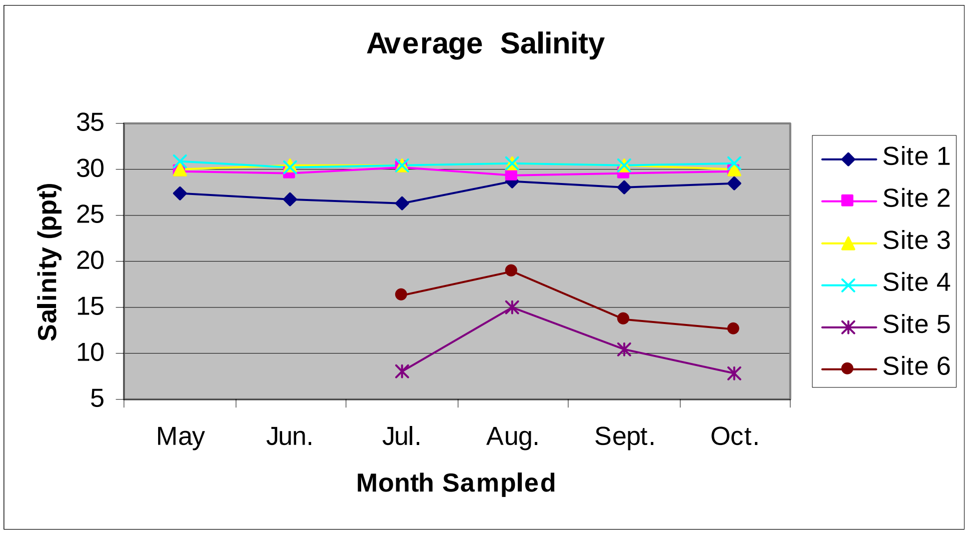
Salinity:

Average salinity in Madaket Harbor is usually around 30 ppt (parts per thousand), average salinity in the open ocean is closer to 32 ppt. Salinity is important with respects to stratification, and biodiversity. As previously discussed the harbor is well mixed, the only area of exception to this is Hither Creek. Because of the exchange with Long Pond through the Madaket Ditch, occurring in relatively small amounts, the salinity gradients in the creek vary widely from the open harbor. Stratification does occur here, and surface salinities have been measured as low as 22 ppt. Though relatively shallow, the difference between top and bottom may be as much as 8 ppt. Salinity and temperature stratifications may adversely affect dissolved oxygen concentrations, especially if there is an oxygen deficiency in the fresh water input.

Long Pond like Madaket Harbor is fairly well mixed, and salinity in any particular water column is largely the same. Variations in salinity occur over the long expanse of the pond, and are affected by tidal forces, as well as fresh water inputs. Site 5, at the southern end of the pond, is usually very fresh, (<10 ppt.). However the August sampling round recorded 10 ppt. at the surface, and 18 ppt. at the bottom. When combined with rainfall data, which showed low precipitation June through August, this data would suggest that the salt water wedge was far reaching during this time period. This would also suggest that the freshness of the pond, not the volume, may be determined by accumulated rainfall. Site 6 also showed an increase in salinity at this time, but more notable is the drop in salinity following an increase in precipitation in September and October.

Different species of aquatic animals often require different salinities at different stages in their life cycles. As such many of these species can sustain variations of salinity ranges. This is best done as adults, however as juveniles, and as larvae, many species have definite salinity requirements. For example winter flounder in their early life cycle prefer salinities around 4 ppt., and herring require almost completely fresh water; as do many anadromous fish species. Oysters may live in salinities as low as 5 ppt. Other shellfish such as bay scallops, have salinity requirements that are much higher (25 ppt for normal development). Further, the larvae of bay scallops can not survive a drop in salinity below 28 ppt.

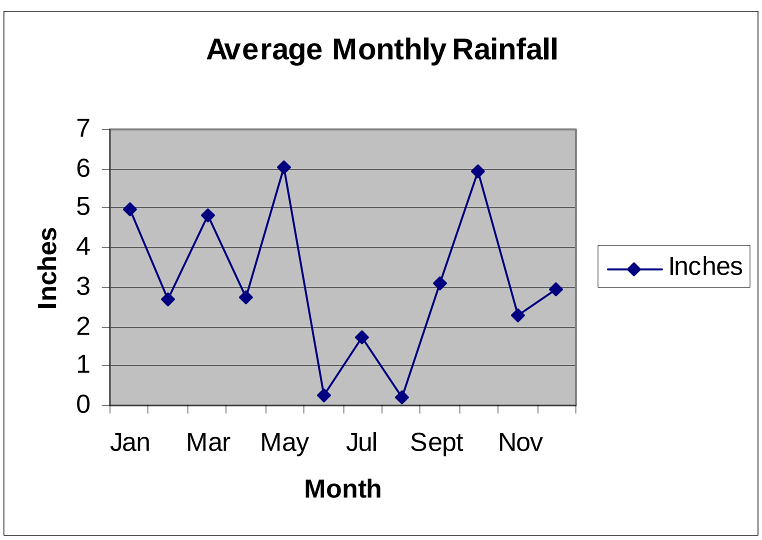
Figure 3: Average Salinity 2005



Rainfall:

Rainfall data corresponds well with salinity changes in Long Pond, and may also be linked to some of the nutrient loading which will be discussed later.

Figure 4: Average Monthly Rainfall 2005



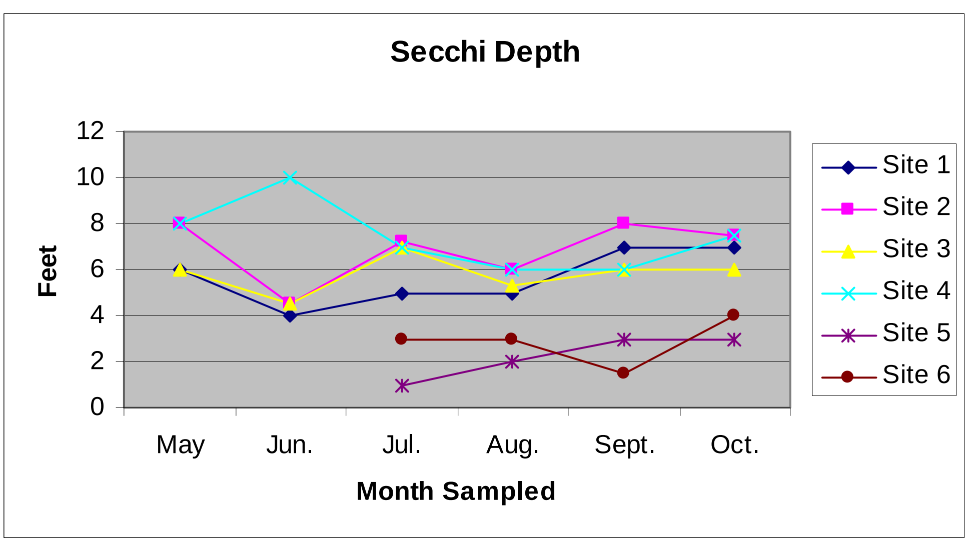
Secchi Depth:

Secchi depth is an approximate measurement of light penetration into the vertical water column. The recorded depth is roughly half the depth that sunlight will reach below the surface of the water. Below this depth photosynthesis is not possible, so a record of this information will provide a rough estimate of potential eel grass habitat. Water transparency is also largely a factor of phytoplankton production, as such it is an indicator of nutrients available in the water column. Generally there are two periods of maximum water clarity prior to and following two major blooms of phytoplankton. Usually these occur at the end of the spring, and just before the winter as water temperatures warm and cool dictating a change in phytoplankton communities.

The microscopic algae known as diatoms, make up the base of primary production in the marine ecosystem. They provide the base of a food web upon which all other marine animals exist, and are normally the dominant species. However, if there is an excessive amount of nutrients and sufficient fresh water inputs in a system, the development of a dinoflagellate community may evolve. In 2005 Nantucket experienced a "Red Tide", the toxic and potentially lethal dinoflagellate *Alexandrium tamerense* closed shellfish beds from 6/2 to 7/5. This was the first known incident for Nantucket, which participates in phytoplankton monitoring for the Division of Marine Fisheries.

Because Madaket Harbor, and Long Pond are shallow water bodies, secchi depths may not always accurately reflect water transparency. In order to get an accurate judgment, secchi depth must be compared to total depth. The Hither Creek station usually has the least amount of light penetration, and this is the result of a combination of problems. The most common contributor is increased turbidity from rainfall. This in conjunction with a silty bottom, and boat traffic in a localized area bring down light penetration considerably. High nutrient concentrations also affect this area as well as the stations in Long Pond, where secchi depths almost never reach the bottom; even in these most shallow locations. Conversely, at the three harbor stations where water quality is good, secchi depths almost always reach the bottom.

Figure 5: Secchi Depth 2005



Nutrients:

Nitrogen:

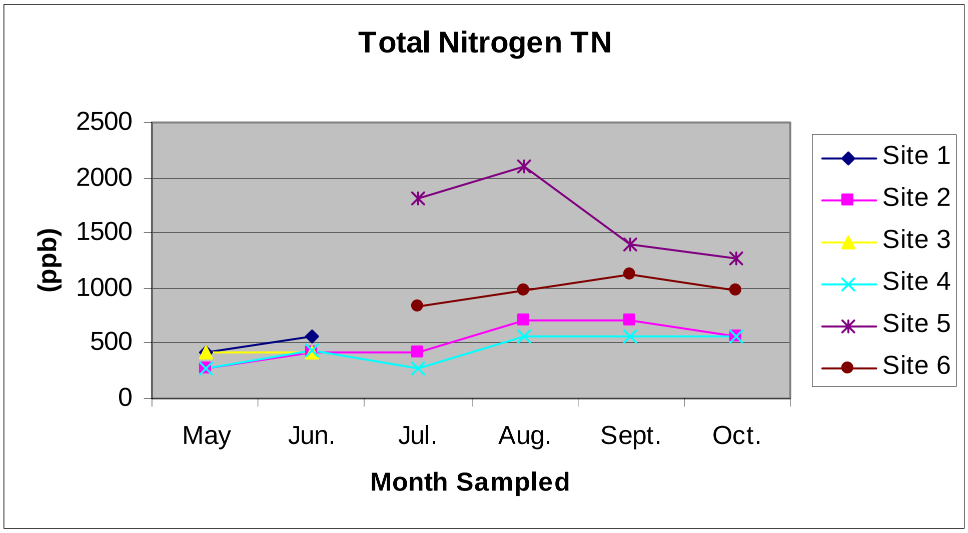
Nitrogen is the limiting nutrient in marine ecosystems, the quantity of which will dictate the health of any particular water body. Nitrogen is not accumulating in Madaket Harbor, primarily because of its open shape, and high rate of circulation. The effects of nitrogen are more prevalent in some areas than others. Total nitrogen includes both organic and inorganic components. Ammonia or NH3 is the only component (Below the Reportable Limit) in Madaket Harbor / Long Pond system (Appendix A). The Department of Environmental Protection for Massachusetts uses some standard classifications based on nitrogen thresholds to describe the health of many marine ecosystem. Madaket Harbor falls between the SA/SB category; and remains in good condition throughout the summer months. These standards can be found in the Estuaries Project Interim Report '03.

Total nitrogen levels in Madaket Harbor were relatively good throughout the summer. Three samples were collected from Site 4 just above 500 ppb, and only two samples were collected from Site 2 at 700 ppb. If these values were consistently in this range, State standards would classify these waters as being moderately impaired. However this condition only develops in August, and doesn't last through October. These higher TN levels are probably the result of inputs from anthropogenic uses in the headwaters of this system. Because Madaket Harbor is flushed so regularly, and is connected to the open Atlantic, it remains in good to fair condition; and may be classified as a mesotrophic water body.

Hither Creek was sampled only twice at the beginning of the summer, because two stations were added in Long Pond to cover a broader range of the system. The creek is known to be an impaired water body, and is permanently closed to shell fishing. The two samples taken in May, and June indicated an already high, and rapidly increasing level. This trend was expected to continue, and was probably the cause for rising nutrient levels in the harbor. This station, and the Warren's Landing station will most likely be added to the sampling regime next year. This will be done in order to confirm the areas involvement in nutrient loading, and to follow declining water quality trends.

Long Pond and its various coves, have the capacity because of circulation patterns to trap nitrogen, and exhibit eutrophic conditions. Combine this with high level of nutrient loading from anthropogenic uses in the watershed, and internal recycling of nutrients, and the result is a severely degraded water body. Nitrogen may not be the most limiting nutrient in Long Pond, as it is closer to a fresh water system, than a salt water one. But it is consistently brackish though, and TN levels are so high that the salinity level may not be the most important factor. The values are at such a magnitude that they are literally off the chart. Site 5 at the southern end in August measured TN at 2,100 ppb, anything above 800 ppb is considered to be hyper-eutrophic. Even Site 6, at the ditch end of the pond recorded TN levels near or above 1,000 ppb for all sampling rounds. Long Pond is so impaired, that it must be exporting nutrients to the ditch, the marsh, the creek, and the harbor. For this reason it must continue to be monitored, with plans for remediation forthcoming.

Figure 6: Total Nitrogen 2005



Phosphorous:

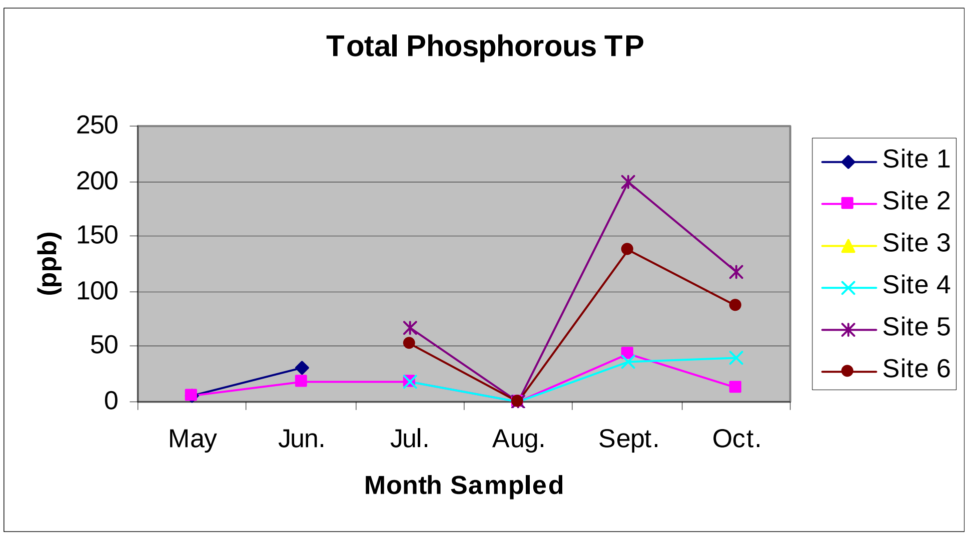
Phosphorous is a limiting nutrient in fresh water, but it is of relative concern to the marine ecosystem. Phosphorous in over abundance can affect the type of phytoplankton species that will be dominant in any system. Blue green algae, dinoflagelates, and nuisance pond weeds are usually associated high nutrients. The level of total phosphorous becomes a problem when values around 50 ppb become prevalent. This level would indicate a eutrophic condition, it would be associated with excessive undesirable plant growth, and anoxic events. A value of 25 ppb TP would be representative of a good/fair mesotrophic system with corresponding nitrogen values around 400 ppb. Phosphorous, like nitrogen is naturally occurring, and would be expected at certain levels based on the geology of any given area. However, the influx of phosphorous from fertilizers, detergents, and septic systems will load a system; and upset the preferred balance.

Loading usually begins in the spring, and lasts through to the end of the summer, when levels are highest. This is most likely related to the seasonal fluctuation of residents on Island, which does not peak until late June. The Madaket Harbor stations recorded fairly low TP levels for most of the summer, and for a marine system this is representative of good water quality. Site 2, and 4 did reach higher levels in September, and Site 4 was pretty high for October. However none of these recorded values were above 50 ppb.

The Hither Creek station is predominantly a salt water system, and was discontinued for nutrient sampling so that the stations in Long Pond could be added. The early TP readings in May and June showed a definite increase over a short time frame, going from 6 to 31 ppb in a month's time. This increasing trend would most likely have continued throughout the summer, based upon the increasing values at other stations. Next year this station will be continually monitored. This will help to determine if TP loading to the creek is localized, or if Long Pond is exporting it's overabundance of phosphorous.

Total Phosphorous in Long Pond was already at a eutrohic level when sampling began in July. Next year sampling will begin much earlier in order to get a complete set of data for the summer. Oddly, in August TP levels dropped to < 15 ppb. This may have been due to the lack of precipitation over the previous three months, including August; (Figure: 4 Average Monthly Rainfall). When precipitation picked up in September there was a dramatic increase, as undoubtedly groundwater was carrying phosphorous from the watershed to the pond. These recorded levels of TP for September were 3x, and 4x higher than needed to create a eutrophic condition. Long Pond may be the most impaired water body on the island.

Figure: 7 Total Phosphorous 2005



Conclusion:

The Madaket Harbor / Long Pond ecosystem is a very important component in Nantucket's overall health, as it makes up one quarter of the island. The harbor remains in good/fair condition, primarily because of it's shape and rapid flushing time. Despite this however it is closed to shell fishing for half the year. This is in large part due to the water quality in Hither Creek, and Long Pond; which may be the most severely degraded water body on the island. The Comprehensive Wastewater Treatment Plan, and the Health Department will be investigating plans for remediation, and conducting inspections of septic systems in the area soon. The Massachusetts Estuary Project should be receiving a nitrogen, and bacteria loading threshold report from the School for Marine Science and Technology very shortly now as well. However, the impact and benefit from these combined efforts will undoubtedly take some time to come into effect. The good news is that the work is in progress. In the mean time the Marine Dept. will continue with it's monitoring regime, and play an active role in preserving, protecting, and the monitoring of this system. Sampling procedures will be expanded upon next year. A qualitative focus will look at macro algae coverage in the harbor. And chlorophyll sampling will be proposed for all stations, in order to better quantify the level of nutrients occurring in this system.

Apendix A

Madaket Harbor / Long Pond 2005

Site 1 Hither Creek
Site 2 Jackson's Pt.
Site 3 Warren's Landing
Site 4 Eel Pt.
Site 5 Massasoit Bridge
Site 6 Long Pond / Madaket Ditch Culvert

Temperature ºC

Site 1	5/26/2005	6/28/2005	7/27/2005	8/25/2005	9/28/2005	10/24/2005
0	10.1	21.5	23.6	23.4	19.5	11.8
3	9.8	21.3	23.6	23.4	20.6	11.8
6	9.6	20.7	23.4	23.8	20.6	11.5
8	9.5			23.8	20.6	11.4

Site 2	5/26/2005	6/28/2005	7/27/2005	8/25/2005	9/28/2005	10/24/2005
0	10	21.1	22.6	22.3	19.2	10.7
3	9.9	20.4	22.6	22.4	19.4	10.9
6	9.8	20	22.6	22.3	19	11.2
8	9.8		22.3	22.2	19	11.3

Site 3	5/26/2005	6/28/2005	7/27/2005	8/25/2005	9/28/2005	10/24/2005
0	9.9	20.7	22.9	21.9	18.9	11.4
3	9.8	20.6	22.9	21.7	18.9	11.4
6	9.9	18.7	22.8	21.5	18.9	11.5
7			22.2			

Site 4	5/26/2005	6/28/2005	7/27/2005	8/25/2005	9/28/2005	10/24/2005
0	9.9	19.2	21.5	21.5	18.7	12.6
3	9.8	19.1	21.5	21.5	18.6	12.6
6	9.8	19	21.5	21.5	18.6	12.6
9	9.9	18.9	21.5			12.6
12		18.8				

Site 5	5/26/2005	6/28/2005	7/27/2005	8/25/2005	9/28/2005	10/24/2005
0	ns	ns	24.5	23.1	20.3	11
2			24.5	26.6	19.7	12.2
4				26.5		12.3

Site 6	5/26/2005	6/28/2005	7/27/2005	8/25/2005	9/28/2005	10/24/2005
0	ns	ns	24.5	23.3	19	10.3
3			24.5	23.7	18.9	10.2
4			24.5	24.1	18.9	10.2

Dissolved Oxygen mg/l

Site 1	5/26/2005	6/28/2005	7/27/2005	8/25/2005	9/28/2005	10/24/2005
0	6.11	5.85	6.62	5.39	6.22	7.39
3	6.5	5.37	6.04	5.43	6.36	7.38
6	6.44	4.2	5.38	4.18	5.56	6.89
8	6.39			4.06	5.33	6.79

Site 2	5/26/2005	6/28/2005	7/27/2005	8/25/2005	9/28/2005	10/24/2005
0	7.3	5.71	7.04	5.53	6.23	7.61
3	7.34	5.62	7.03	5.65	6.34	7.58
6	7.32	5.61	7.16	5.62	5.94	7.54
8	7.24		7.23	5.59	5.9	5.34

Site 3	5/26/2005	6/28/2005	7/27/2005	8/25/2005	9/28/2005	10/24/2005
0	7.17	5.99	6.78	6.22	6.41	7.53
3	7.12	6.02	7.07	6.3	6.43	7.44
6	7.39	6.13	7.24	6.35	6.49	7.23
7			7.55			

Site 4	5/26/2005	6/28/2005	7/27/2005	8/25/2005	9/28/2005	10/24/2005
0	7.25	5.79	7.97	6.18	6.77	7.64
3	7.18	5.77	7.94	6.28	6.78	7.54
6	7.18	5.79	7.91	6.3	6.71	7.62
9	7.21	5.82	7.9			7.63
12		5.82				

Site 5	5/26/2005	6/28/2005	7/27/2005	8/25/2005	9/28/2005	10/24/2005
0	ns	ns	12.68	7.34	6.75	8.01
2			12.73	2.69	7.18	6.86
4				1.72		1.21

Site 6	5/26/2005	6/28/2005	7/27/2005	8/25/2005	9/28/2005	10/24/2005
0	ns	ns	6.78	6.94	8.02	8.89
3			6.42	6.51	7.93	8.75
4			6.21	6.27	7.14	8.71

Salinity ppt.

Site 1	5/26/2005	6/28/2005	7/27/2005	8/25/2005	9/28/2005	10/24/2005
0	24.2	19.8	22.5	27.7	24.6	27.9
3	27	30.1	26.6	28.4	28.8	28
6	29.1	30.1	29.9	29.6	29.4	29
8	29.5			29.6	29.5	29.2

Site 2	5/26/2005	6/28/2005	7/27/2005	8/25/2005	9/28/2005	10/24/2005
0	29.6	28.2	30.1	29.2	28.2	29.1
3	29.7	30.1	30.1	29.2	30	29.6
6	29.9	30.1	30.3	29.6	29.9	29.9
8	29.9		30.3	29.6	29.9	30.1

Site 3	5/26/2005	6/28/2005	7/27/2005	8/25/2005	9/28/2005	10/24/2005
0	29.9	30.3	30.4	30.6	30.3	30
3	29.9	30.6	30.4	30.5	30.4	30
6	30.3	30.2	30.5	30.6	30.4	29.9
7			30.5			

Site 4	5/26/2005	6/28/2005	7/27/2005	8/25/2005	9/28/2005	10/24/2005
0	30.8	30.3	30.4	30.6	30.5	30.7
3	30.8	30.3	30.4	30.6	30.5	30.7
6	30.8	30.4	30.4	30.6	30.5	30.7
9	30.7	30.3	30.4			30.7
12		30.3				

Site 5	5/26/2005	6/28/2005	7/27/2005	8/25/2005	9/28/2005	10/24/2005
0	ns	ns	8	10	10.5	7.1
2			8	17.4	10.6	8.2
4				18		8.3

Site 6	5/26/2005	6/28/2005	7/27/2005	8/25/2005	9/28/2005	10/24/2005
0	ns	ns	16.2	18.1	13.6	12.7
3			16.3	18.6	13.7	12.7
4			16.4	19.9	14.1	12.8

Secchi ft.

	5/26/2005	6/28/2005	7/27/2005	8/25/2005	9/28/2005	10/24/2005
Site 1	6	4	5	5	7	7
Site 2	8	4.5	7.2	6	8	7.5
Site 3	6	4.5	7	5.3	6	6
Site 4	8	10	7	6	6	7.5
Site 5	ns	ns	1	2	3	3
Site 6	ns	ns	3	3	1.5	4

Nitrate NO3 (ppb)

	5/26/2005	6/28/2005	7/27/2005	8/25/2005	9/28/2005	10/24/2005
Site 1	BRL	10	ns	ns	ns	ns
Site 2	BRL	BRL	BRL	BRL	BRL	BRL
Site 3	BRL	BRL	ns	ns	ns	ns
Site 4	BRL	10	BRL	BRL	BRL	BRL
Site 5	ns	ns	BRL	BRL	BRL	BRL
Site 6	ns	ns	BRL	BRL	BRL	BRL

Organic Nitrogen TKN (ppb)

	5/26/2005	6/28/2005	7/27/2005	8/25/2005	9/28/2005	10/24/2005
Site 1	420	560	ns	ns	ns	ns
Site 2	280	420	420	700	700	560
Site 3	420	420	ns	ns	ns	ns
Site 4	280	420	280	560	560	560
Site 5	ns	ns	1,820	2,100	1,400	1,260
Site 6	ns	ns	840	980	1,120	980

Total Nitrogen TN (ppb)

	5/26/2005	6/28/2005	7/27/2005	8/25/2005	9/28/2005	10/24/2005
Site 1	420	570	ns	ns	ns	ns
Site 2	280	420	420	700	700	560
Site 3	420	420	ns	ns	ns	ns
Site 4	280	430	280	560	560	560
Site 5	ns	ns	1,820	2,100	1,400	1,260
Site 6	ns	ns	840	980	1,120	980

Amonia NH3 (ppb)

	5/26/2005	6/28/2005	7/27/2005	8/25/2005	9/28/2005	10/24/2005
Site 1	BRL	BRL	ns	ns	ns	ns
Site 2	BRL	BRL	BRL	BRL	BRL	BRL
Site 3	BRL	BRL	ns	ns	ns	ns
Site 4	BRL	BRL	BRL	BRL	BRL	BRL
Site 5	ns	ns	BRL	BRL	BRL	BRL
Site 6	ns	ns	BRL	BRL	BRL	BRL

Total Phosphorous TP (ppb)

	5/26/2005	6/28/2005	7/27/2005	8/25/2005	9/28/2005	10/24/2005
Site 1	6	31	ns	ns	ns	ns
Site 2	6	19	18	<15	43	13
Site 3	BRL	BRL	ns	ns	ns	ns
Site 4	BRL	BRL	18	<15	37	40
Site 5	ns	ns	67	<15	200	117
Site 6	ns	ns	52	<15	138	87

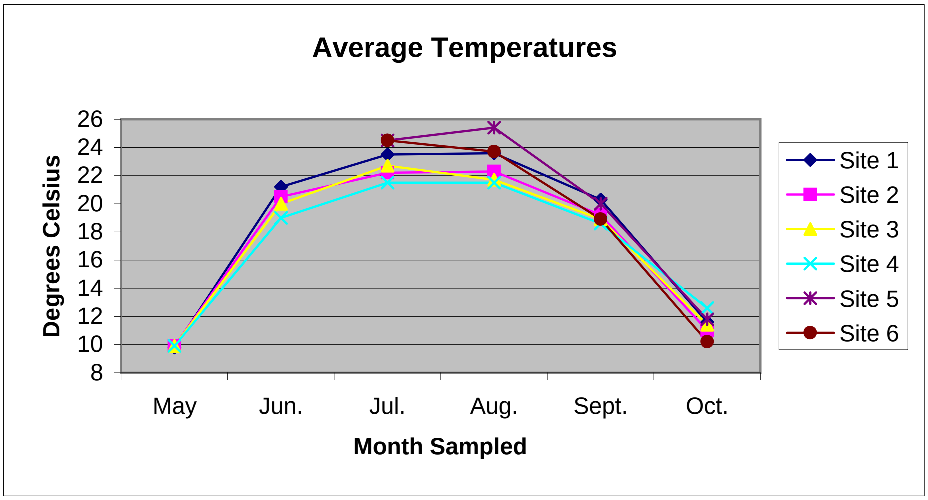
ns = not sampled
BRL = below reportable limit

Appendix B

Madaket Harbor / Long Pond Average Physical and Chemical Averages 2005

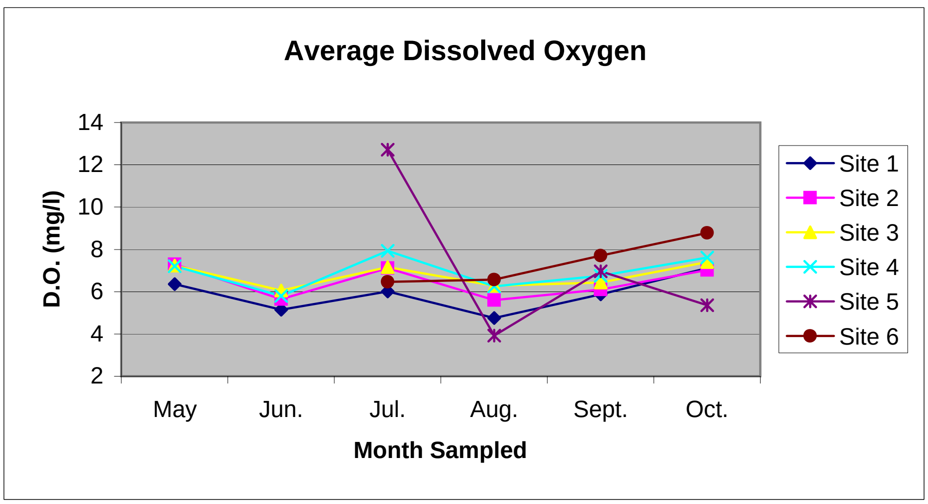
Average Temperature (ºC)

	May	Jun.	Jul.	Aug.	Sept.	Oct.
Site 1	9.8	21.2	23.5	23.6	20.3	11.6
Site 2	9.9	20.5	22.2	22.3	19.2	11
Site 3	9.9	20	22.7	21.7	18.9	11.4
Site 4	9.9	19	21.5	21.5	18.6	12.6
Site 5			24.5	25.4	20	11.8
Site 6			24.5	23.7	18.9	10.2



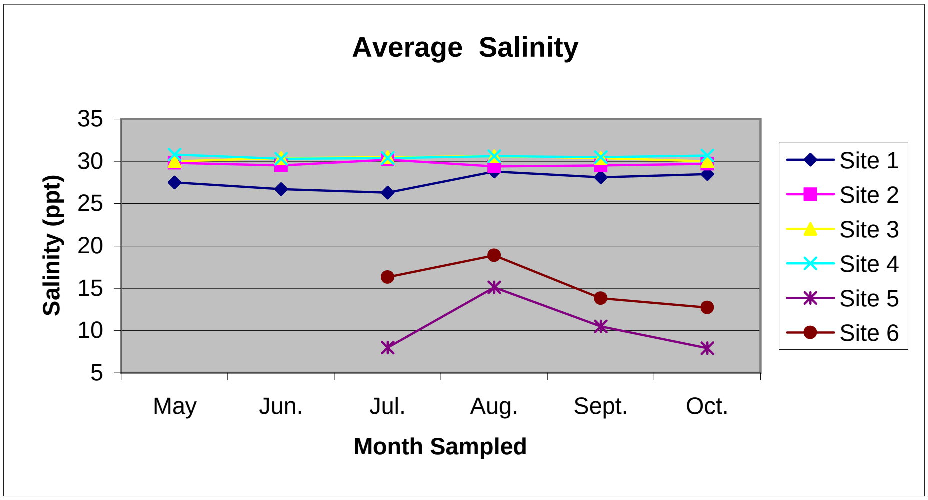
Average Dissolved Oxygen (mg/l)

	May	Jun.	Jul.	Aug.	Sept.	Oct.
Site 1	6.36	5.14	6.01	4.76	5.87	7.11
Site 2	7.3	5.65	7.12	5.6	6.1	7.02
Site 3	7.23	6.05	7.16	6.29	6.44	7.4
Site 4	7.21	5.8	7.93	6.25	6.75	7.61
Site 5			12.71	3.92	6.97	5.36
Site 6			6.47	6.57	7.7	8.78



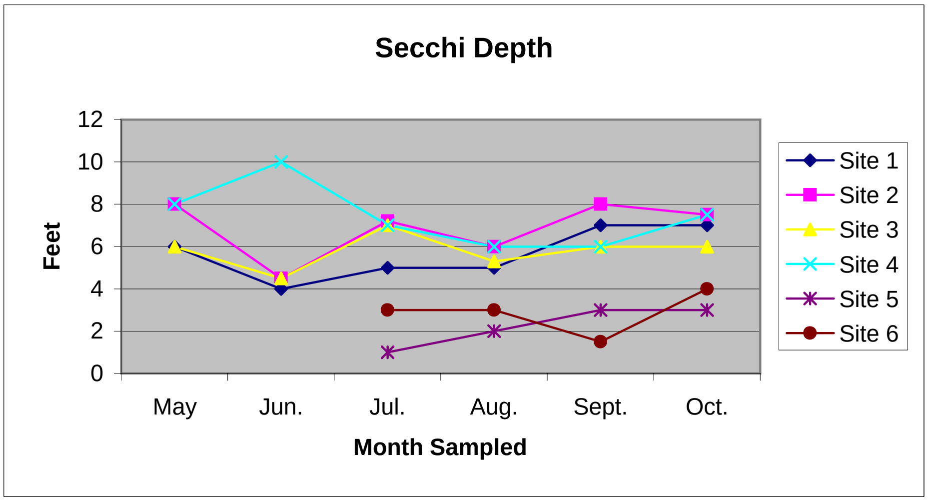
Average Salinity (ppt)

	May	Jun.	Jul.	Aug.	Sept.	Oct.
Site 1	27.5	26.7	26.3	28.8	28.1	28.5
Site 2	29.8	29.5	30.2	29.4	29.5	29.7
Site 3	30	30.4	30.5	30.6	30.4	30
Site 4	30.8	30.3	30.4	30.6	30.5	30.7
Site 5			8	15.1	10.5	7.9
Site 6			16.3	18.9	13.8	12.7



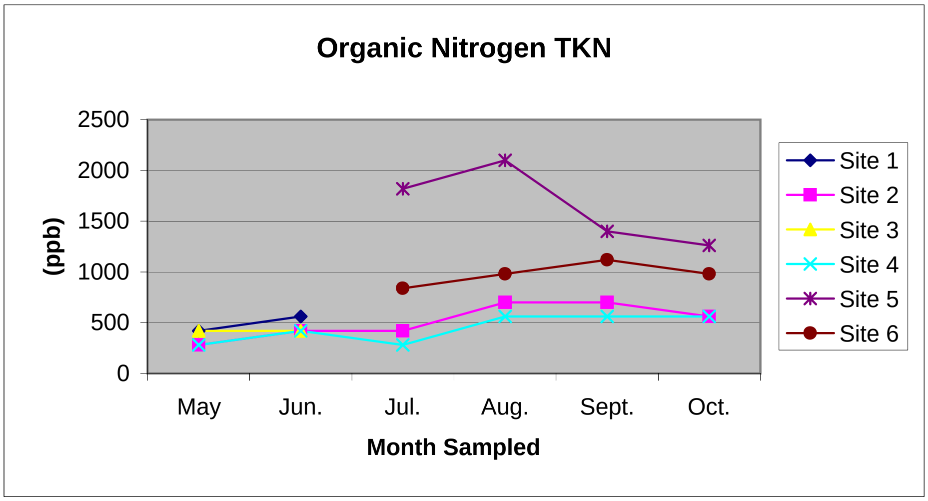
Secchi ft.

	May	Jun.	Jul.	Aug.	Sept.	Oct.
Site 1	6	4	5	5	7	7
Site 2	8	4.5	7.2	6	8	7.5
Site 3	6	4.5	7	5.3	6	6
Site 4	8	10	7	6	6	7.5
Site 5			1	2	3	3
Site 6			3	3	1.5	4



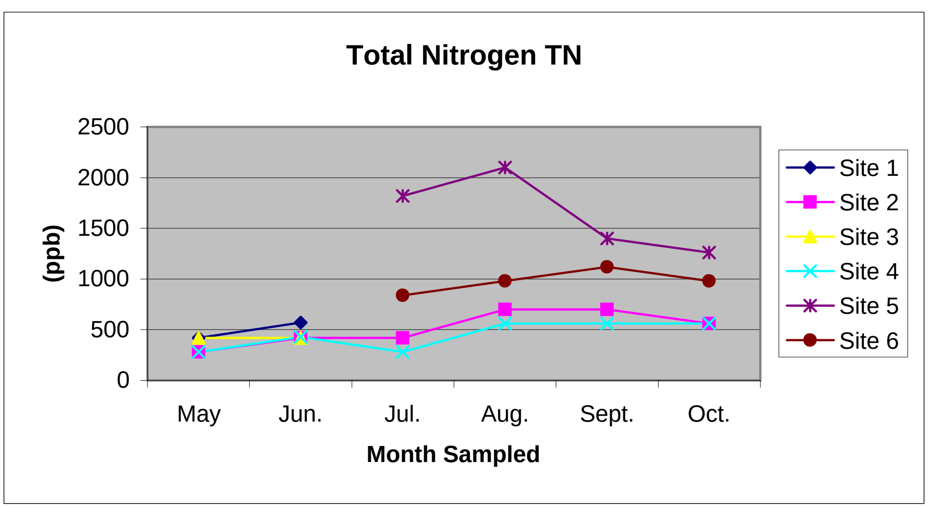
Organic Nitrogen TKN (ppb)

	May	Jun.	Jul.	Aug.	Sept.	Oct.
Site 1	420	560				
Site 2	280	420	420	700	700	560
Site 3	420	420				
Site 4	280	420	280	560	560	560
Site 5			1,820	2,100	1,400	1,260
Site 6			840	980	1,120	980



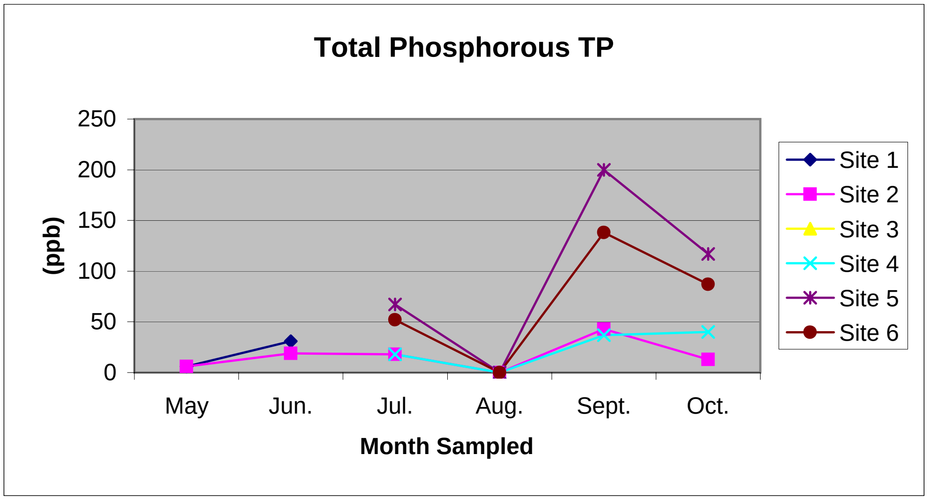
Total Nitrogen TN (ppb)

	May	Jun.	Jul.	Aug.	Sept.	Oct.
Site 1	420	570				
Site 2	280	420	420	700	700	560
Site 3	420	420				
Site 4	280	430	280	560	560	560
Site 5			1,820	2,100	1,400	1,260
Site 6			840	980	1,120	980



Total Phosphorous TP (ppb)

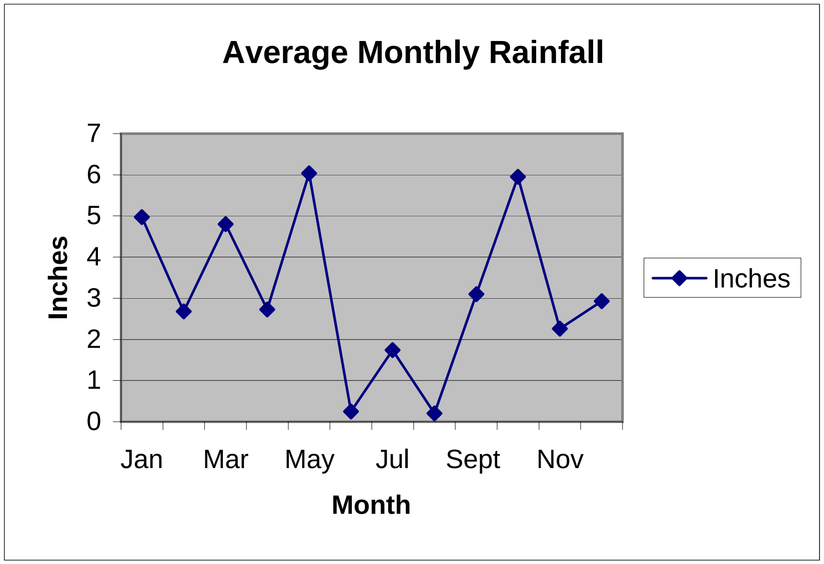
	May	Jun.	Jul.	Aug.	Sept.	Oct.
Site 1	6	31				
Site 2	6	19	18	<15	43	13
Site 3						
Site 4			18	<15	37	40
Site 5			67	<15	200	117
Site 6			52	<15	138	87



Appendix C

Average Monthly Rainfall 2005

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Inches	4.97	2.68	4.8	2.73	6.04	0.25	1.74	0.2	3.1	5.95	2.26	2.93



Total Rainfall: 37.65 "